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ON A PNEUMATIC APPARATUS FOR VALUING THE RESPIRATORY POWERS WITH RELATION TO HEALTH.

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Abstract.

Mr. Hutchinson's apparatus* for valuing the respiratory organs consists of two instruments, the one for measuring "volume," or the number of cubic inches of air thrown out of the chest, and the other for estimating the "power" by which that air can be drawn in and given out.

The instrument for measuring the volume is called the "breathing machine;" other names have been given to it, as "stethometer," or "pulmometer;" but as the stethoscope is sometimes strangely miscalled, and as those who have been submitted to its application have been said to have been "stereotyped," the author thought it better to denominate this machine by some more intelligible appellation.

It consists of two cylinders, one within the other, similar to the great receivers used in gas-works. The outer cylinder contains water, while the inner cylinder, being inverted, is intended to receive the breath, and hence is termed the *receiver;* the breath raises the inner

* A paper, by Mr. Hutchinson, on the results obtained by means of the pneumatic apparatus, was read before the Statistical Society of London on the evening of June 17th, 1844, and which is contained in the "Quarterly Journal" of that Society for September last.

cylinder according to the air thrown out of the lungs. The receiver is carefully counterbalanced by two weights, contained in two vertical brass tubes or hollow columns. There are also two other hollow columns standing in the same line, and on the same base as those containing the weights, but nearer to the cylinders. These inner hollow columns have each a slot, in which the cross-head of the receiver works vertically up and down; a cord is fastened to each end of the cross-head, and, passing over pulleys, is attached to the weights already mentioned. These weights form the counterbalance of the receiver, which counter-balance is made rather heavier than the receiver, in order that there may be no strength unnecessarily lost by the individual under examination, so that muscular exertion is required only to contract the chest, and not to elevate the receiver; thus the counterbalance weights may be considered to act as a suction-pump, by drawing the breath out of the lungs. The receiver, being elevated by the breath, and it being desirable to ascertain how much air has been given out, a scale is attached to the receiver, which ascends and descends with it. This scale is graduated with lines corresponding with cubic inches, calculated according to the contents of the receiver; according, therefore, to the elevation of the receiver *from the surface* of the reservoir, there must be so many cubic inches in the receiver, and the level of the water must be taken as the standard line from which the number of cubic inches is to be determined. The arrangement for accomplishing this is by bringing a glass tube up in front of the scale, the water in which tube is connected with that in the reservoir, and hence the water in the tube must be at the same level with that in the reservoir; the operator

has, therefore, only to ascertain what degree on the scale the water in the tube corresponds with, which degree being numbered determines the total number of cubic inches contained in the reservoir at any elevation. The whole apparatus is levelled before taking an observation by means of proper adjusting screws. The breath enters the receiver by a tube which passes up through the reservoir water, and when the experiment is concluded, and the receiver is to be drawn down again, the air is discharged by a second tube. Sometimes the water in the reservoir is liable to be wasted by injudicious management, as by endeavouring to press down the receiver without allowing the air to escape by the air tube; to avoid such an inconvenience, the cylinder, which contains the reservoir water, is surrounded by a casing, which allows a space between, into which the water under such neglect will be discharged, and the resistance caused by the water of the reservoir, in case of such error being committed, immediately arouses the attention of the operator, so that no water can be actually wasted. A thermometer is fixed in the top of the receiver to note the temperature of the expired air after an observation, the temperature of this expired air is always corrected, and reduced or raised, as the case may require, to 60°. The temperature of the breath is always the same as that of the reservoir, which varies but little, hence the correction to be made is generally trifling; for this reason a large quantity of water is used.

Three taps are introduced at the bottom of the machine; one fixed on the left side is for drawing off the water when it is desired to empty the reservoir, and one on the right is connected with the tube used for discharging the breath through; and as the individual under

examination does sometimes by mistake the very reverse of what he ought to do by drawing air into his chest from the breathing machine, it follows that the water of the reservoir will fall into the vertical tubes, to remove which a third tap is fixed midway between the right-hand and left-hand tap.

The machine for valuing the power by inspiration and expiration, is of a very different order of construction to the "breathing machine." The principle adopted is that of elevating, by the power of the muscles of inspiration and expiration, a column of mercury, and according to the inches of elevation to determine the relative power exerted by these muscles.

It consists of a dial-plate, graduated into inches and tenths of inches; the plate is divided by a line perpendicularly, the *left* half is graduated for measuring inspiration, the *right* half for that of expiration. Certain words are engraved on each side thereof, but which do not correspond with each other in numerical value, because the power of *expiration* is *stronger* than that of *inspiration*.

The following table represents these words, opposite to which are marked the figures; those on the left as *Inspiration*, and those on the right as *Expiration*.

Inspiration. Inches.		*Expiration.* Inches.
1·5	Weak	2·0
2·0	Ordinary	2·5
2·5	Strong	3·5
3·5	Very Strong	4·5
4·5	Remarkable	5·8
5·5	Very Remarkable	7·0
6·0	Extraordinary	8·5
7·0	Very Extraordinary ..	10·0

These expressions of power are obtained from the results of nearly 1200 observations.

Mercury is contained in a bent tube, one end of which is surmounted by a flexible tube, having a nose-piece attached, which is made of Indian-rubber, so cut and perforated as to allow the breath to pass through it without any escape taking place, even under the most violent exertion. Upon the surface of the mercury is a weight, to which is attached a silk thread; this thread is carried upwards, and taking one turn and a half round a wheel placed opposite the centre of and behind the dial-plate, and thence passing downwards, is secured to a counterbalance weight. Upon blowing into the tube the mercury is depressed in one of its legs, while it is elevated in the other, at the same time carrying with it a weight; while the counterbalance weight sinking, causes the wheel to revolve, and thus moves the pointer attached thereto, which indicates the inches of elevation on the dial-plate. The dial and tube are supported upon an upright piece of wood, maintained in that position by cross-feet.